Issues in Developing an Operational Forecast Capability for Coastal Waters

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DEVELOPMENT OF A FORECAST SYSTEM

Advantages

The application of a numerical model to the prediction of coastal circulation has economic advantages over the maintenance of dense and varied observational networks. Models typically contain higher spatial and temporal resolution than measured values which are spatially sparse and subject to temporal dropout. A model that incorporates the range of important dynamical forcing and represents complex shorelines and bathymetry at fine scales can be exercised as a virtual laboratory for understanding the cause and effect of existing currents and subsequently for developing contingency plans under various emergency scenarios.

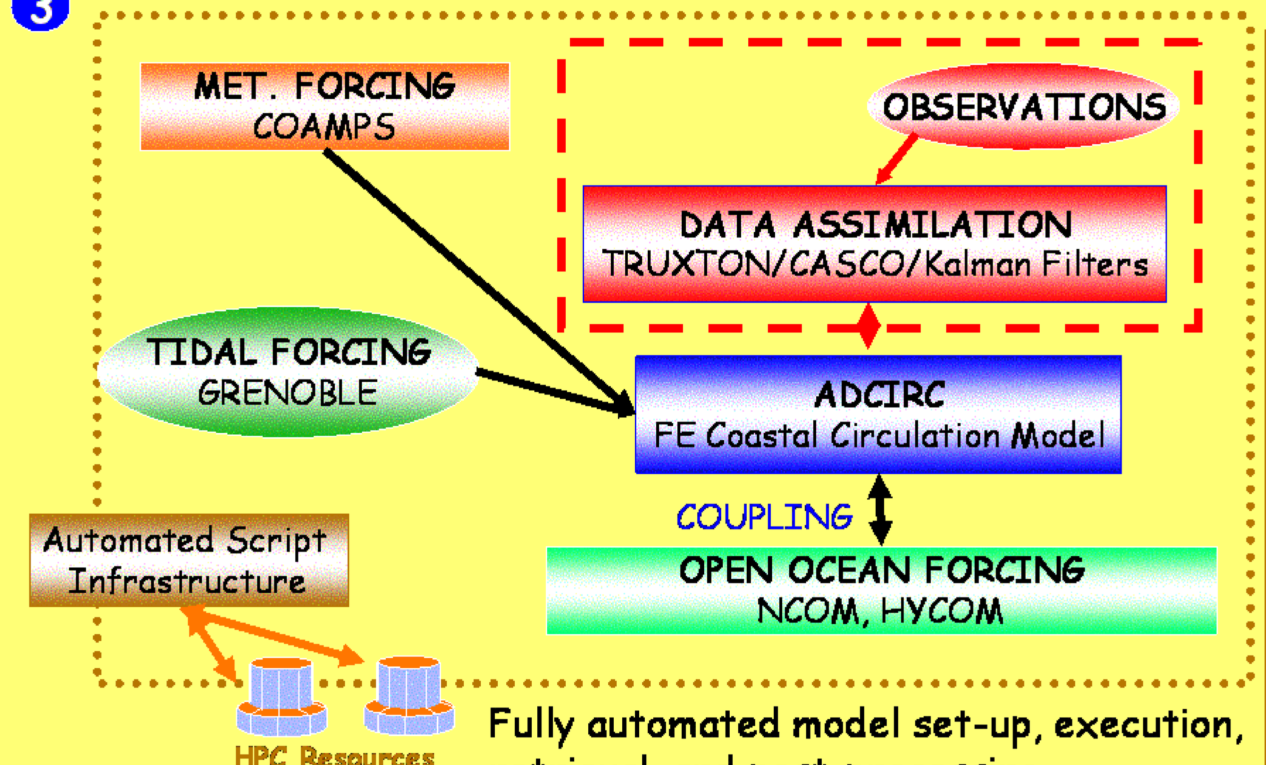
Criteria for Success

1. Accurate and flexible dynamical model
2. Rapid re-location to other regions with varied processes
3. Ability to meet operational time constraints
4. Generation of meaningful operational products
5. Quantification of model forecast skill and sensitivities to bathymetry, forcing (type and resolution), and the representation of dynamical processes

1 The Dynamical Model: ADCIRC

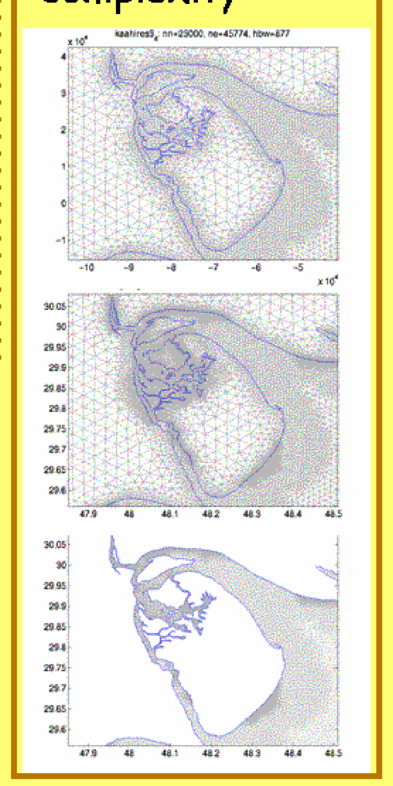
- 2D and 3D Shallow Water Hydrodynamics
- Coastal processes associated with:
  - tides, wind, waves, rivers
  - shoreline inundation/recession
  - baroclinic development (i.e. transport equations)
- Finite element-based discretization
- MPI implementation
- Data assimilation capability (under development)

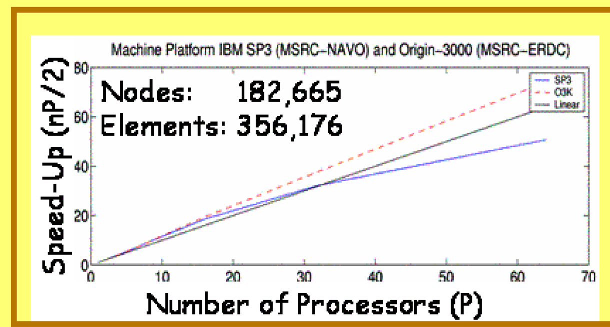
2 3 Automated, Rapid, Re-locatable Forecast System



Fully automated model set-up, execution, retrieval, and post-processing

Automated grid generation based on refinement by depths and geometric complexity





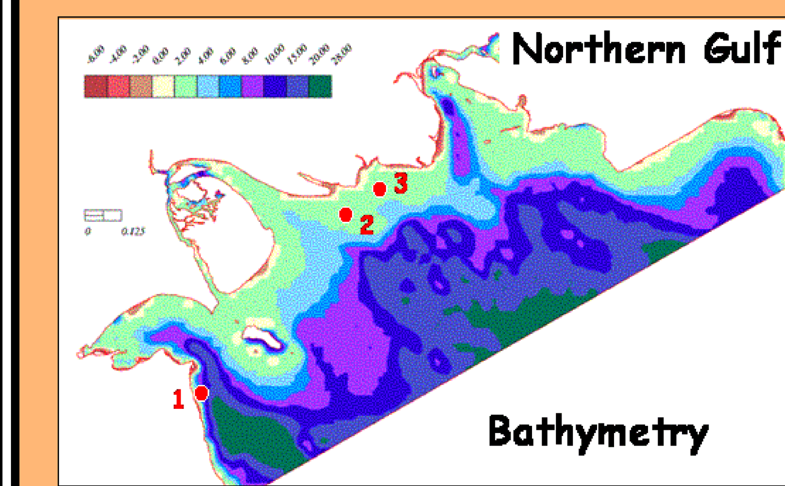
Efficient, realizing near-linear speedup using MPI on parallel computer platforms.

Portable across all computer platforms to date.

A RECENT APPLICATION of the ADCIRC COASTAL FORECAST SYSTEM

KAA Region, Persian Gulf in Support of *Operation Iraqi Freedom*, March 2003

Limited Area Model Domain

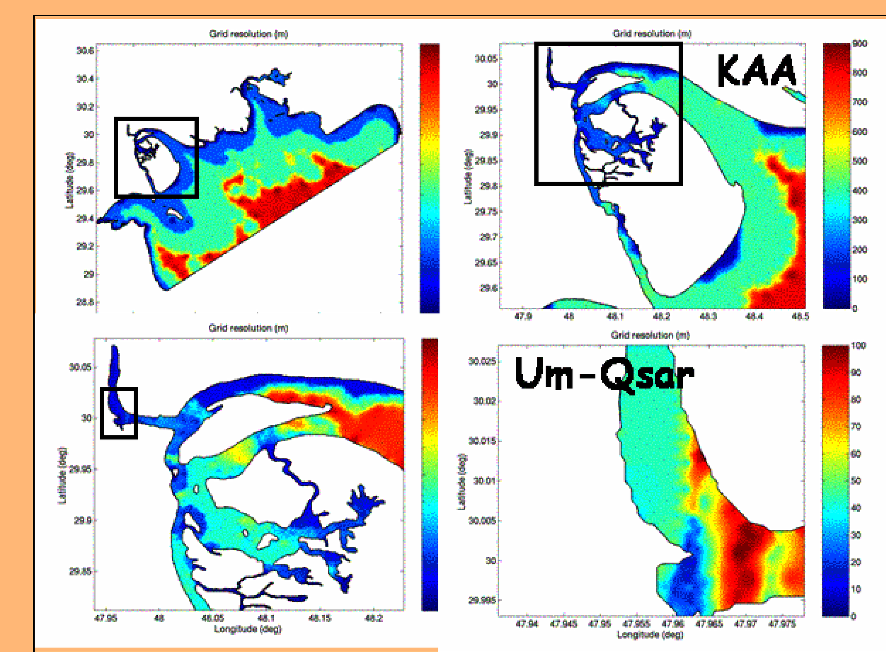


6m (above sea level) – 28 m depth

IHO Tidal Elevation Stations:

1. Mina-Al-Ahmadi
2. Shat-al-Arab
3. Khor-Musa

Finite Element Mesh Resolution

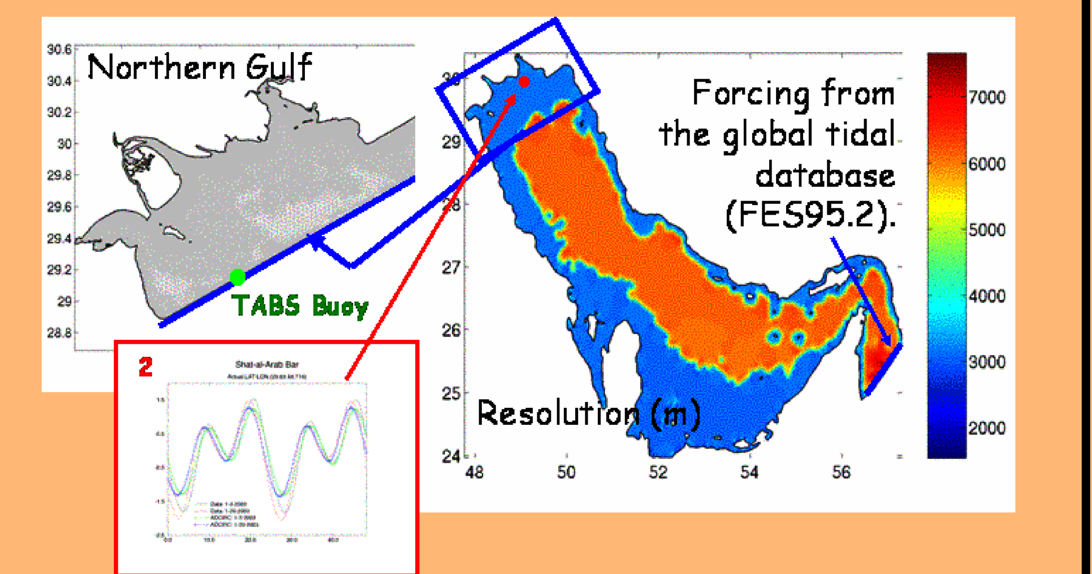


Fine Resolution: 2 m – 1 km

\# nodes: 247,767
\# elements: 480,001

Offshore Tidal Forcing

Large domain ADCIRC results used for forcing at the Northern Gulf open boundary

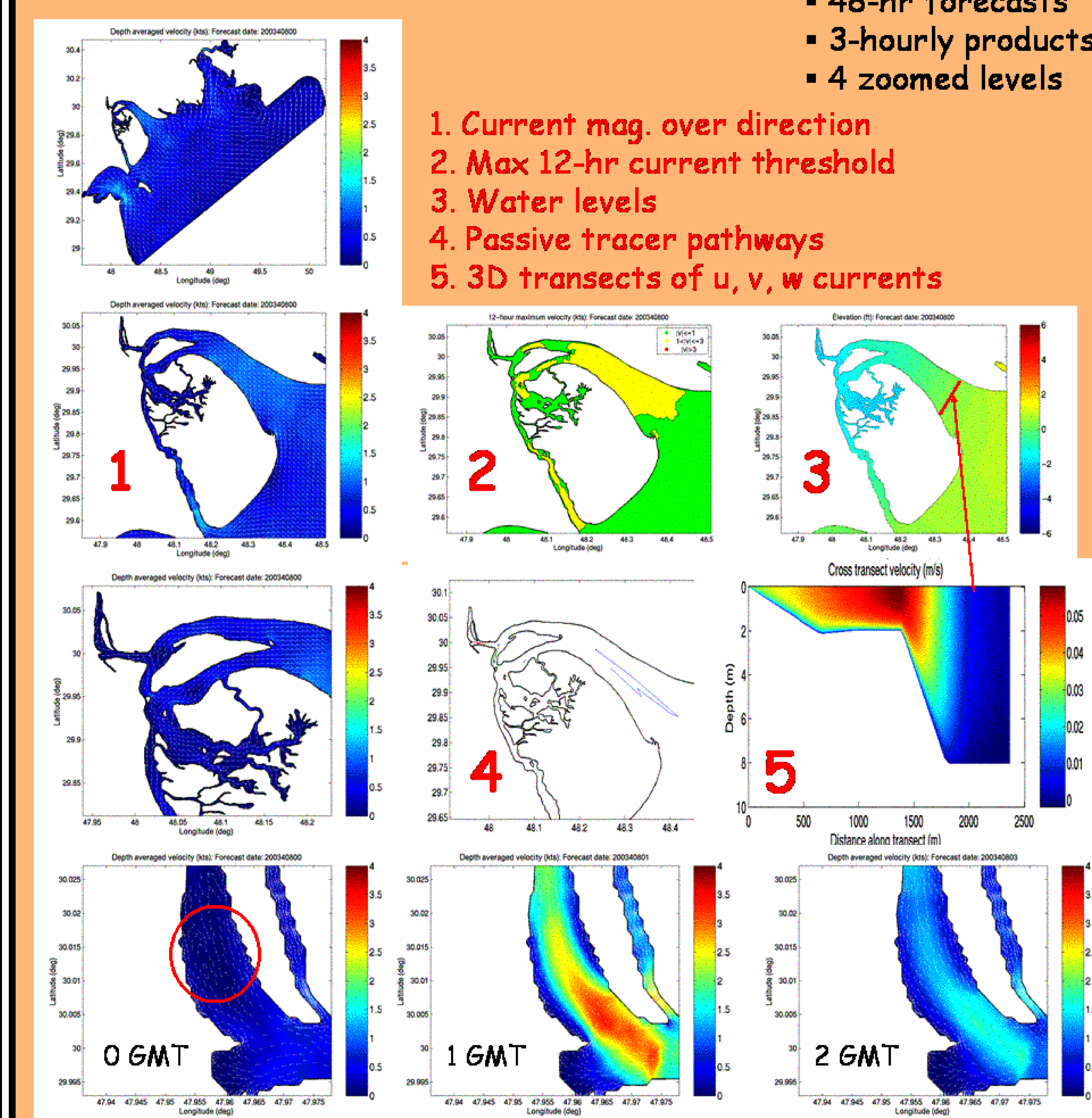


Wind Forcing: COAMPS 10-m winds

4 Meaningful Operational Products

- 48-hr forecasts
- 3-hourly products
- 4 zoomed levels

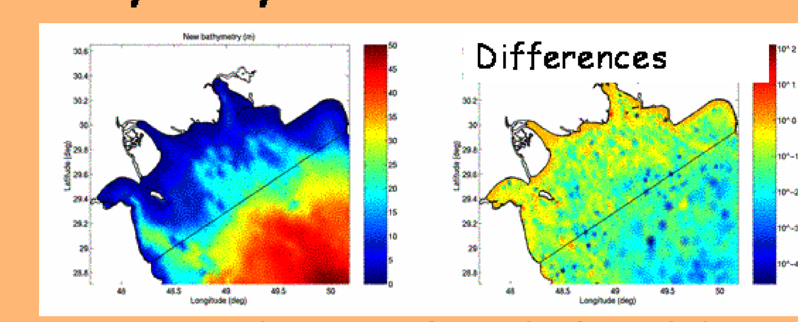
1. Current mag. over direction
2. Max 12-hr current threshold
3. Water levels
4. Passive tracer pathways
5. 3D transects of u, v, w currents

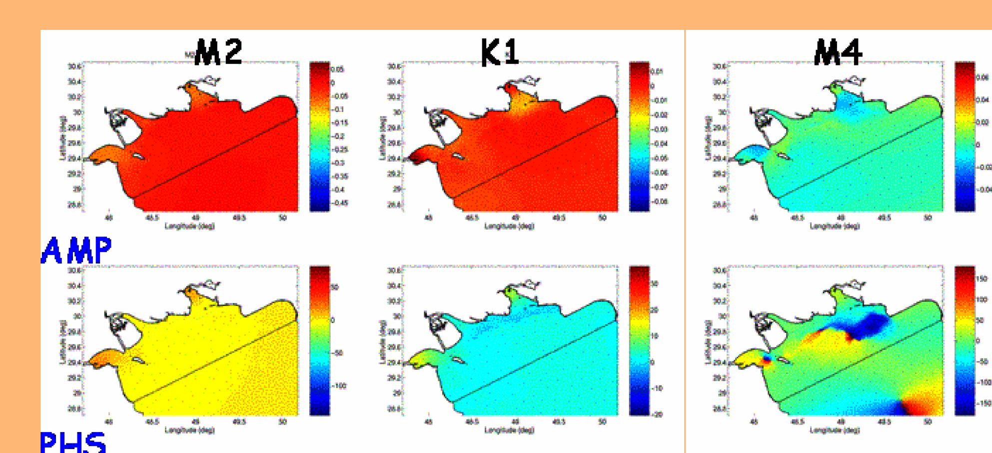


At Um Qsar, meter resolution captures the development of an eddy, creating a high shear zone. The local variability of the currents necessitates hourly temporal resolution of the forecast products.

5 Model Sensitivities

Bathymetry: 1-minute vs. 2-minute resolution

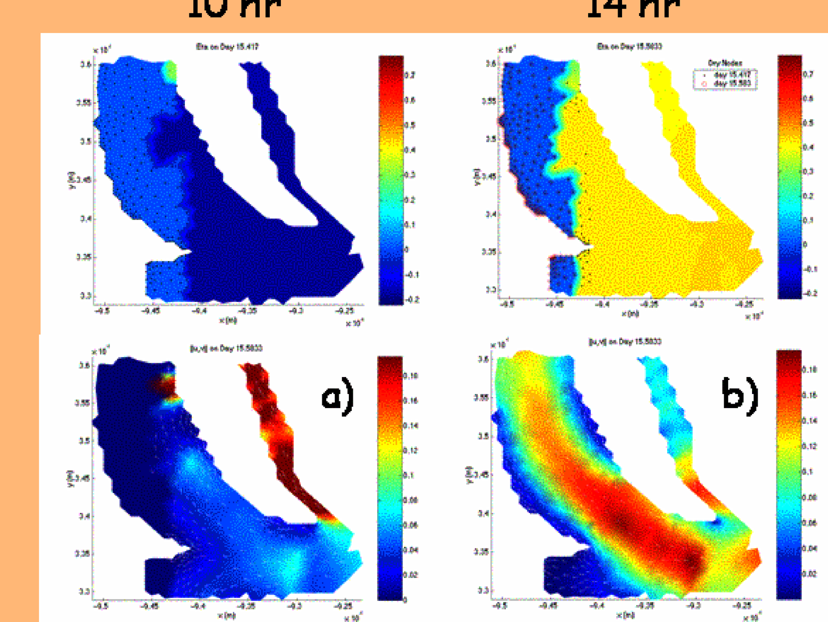




Sensitivities of the primary tidal constituent amplitudes and phases to bathymetry differences are not nearly as pronounced as for the nonlinear tides, i.e. M4.

Areas having the largest tidal differences correspond to the most significant bathymetric changes from the 2-minute to the 1-minute data sources.

Shoreline Inundation



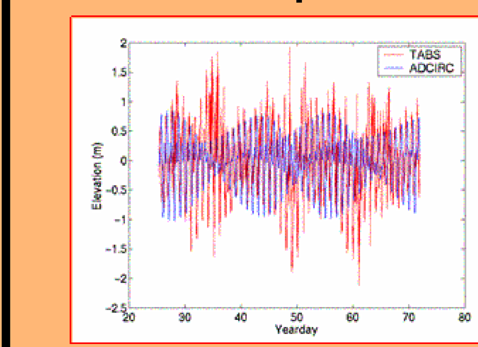
Water levels at 4 hour intervals. Areas that remain dry are delineated by circled dots. Previously dry areas now wet are marked by dots.

Current direction over magnitude at the same time for shoreline inundation a) active and b) not active.

Accuracy of the shoreline inundation mechanism depends highly on bathymetry data.

5 Model Skill

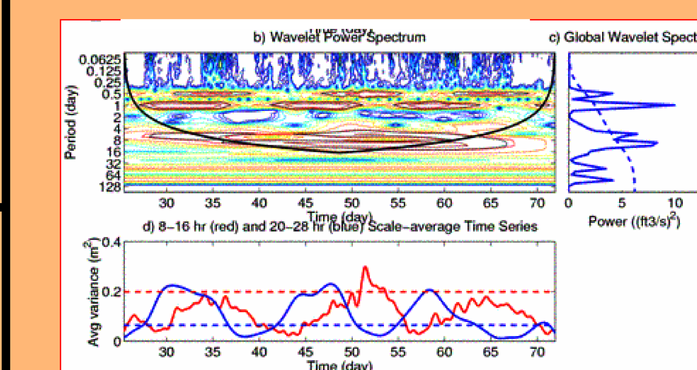
TABS Buoy Elevations



RMSE 0.71 m

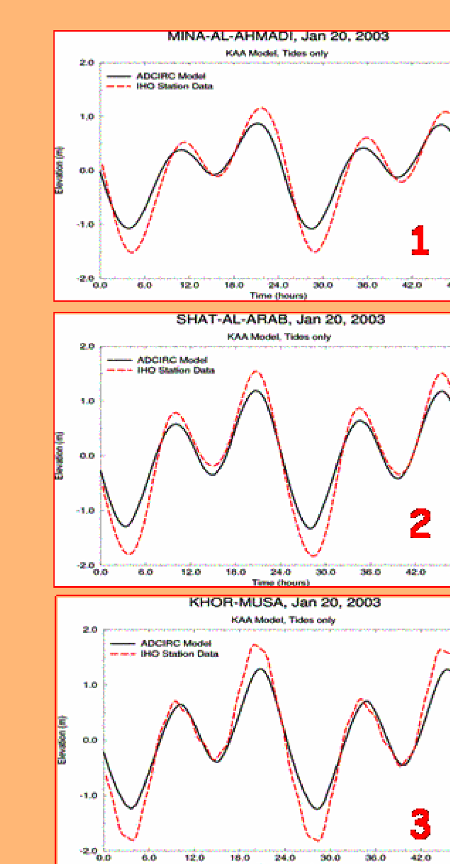
MAE 0.59 m

Errors at the model boundary likely due to the presence of a fortnightly signal.



The wavelet power spectrum shows periodicity on a fortnightly time scale in both the semi-diurnal and diurnal tidal signals. Time series of scale-averaged variance (solid) shows that diurnal (blue) and semi-diurnal (red) signals are 180 deg out of phase, and peaks well exceed the 95% confidence level (dashed).

IHO Elevations



Errors average 10 cm in amplitude and 30 minutes in phase.